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Attention-Based Mask Regional Convolutional Neural Network for Delineation of Multiple Organs in Head-And-Neck MRI

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INTRODUCTION

A considerable increase in the use of magnetic resonance imaging (MRI) in radiation therapy has been seen in the past decades due to the superb soft-tissue contrast provided by MRI. MRI has the potential to significantly improve the accuracy of target and organs-at-risk (OARs) delineation, which may then improve clinical outcomes of radiotherapy in a variety of cancer types.

MRI-only workflows in radiotherapy improves the efficiency of treatment while generating more technical requirements in MRI, among which, the fully automatic multi-organ segmentation is an initial step. The accuracy of automatic organ contouring highly affects the precision of dose calculation and assessment.

AIM

Organs-at-risk (OARs) delineation is labor-intensive, time-consuming and subjective. This study aims to develop a fully automatic multi-organ segmentation in MRI in head-and-neck (HN) cancer radiotherapy using a novel deep learning-based algorithm, namely, attention-based mask scoring regional convolutional neural network (AMS-RCNN).

METHOD

Attention-based mask scoring regional convolutional neural network (AMS-RCNN) method was developed. For a given pair of MR image and its corresponding manual multi-organ contours (made by experienced physicians), the contours are used as the learning-based target of the MR image.

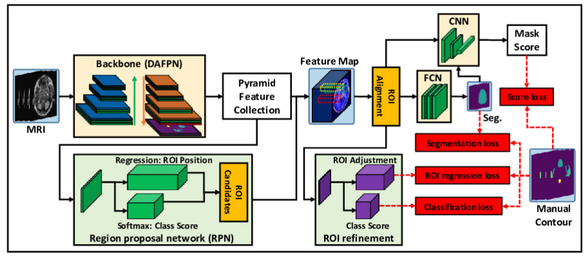

Figure 1. Schematic flow chart of the proposed algorithm

RESULTS

- MR images from 45 HN cancer patients were acquired using a Siemens scanner to evaluate our proposed method. Manual contours made by experienced physicians were used as the ground truth for training and testing the proposed model.
- The Dice similarity coefficient (DSC) between the ground truth and segmentation was to quantitatively evaluate the performance of the proposed method.
- Five-fold cross-validation experiments were used to evaluate the proposed method. The 45 patients' data were first randomly grouped to five equal sized subgroups. Then, for each experiment we took one subgroup as either the test or validation data set and trained the model on the remaining four subgroups. The experiment repeated five times to force each subgroup to be used as test data once.

Table 1. Numerical results of the proposed method.

Mean	Esophagus	Larynx	Mandible	Oral Cavity	Left Parotid	Right Parotid	Pharynx	Spinal Cord
DSC	0.84±0.04	0.79±0.06	0.85±0.04	0.89±0.03	0.82±0.04	0.81±0.04	0.85±0.06	0.89±0.02

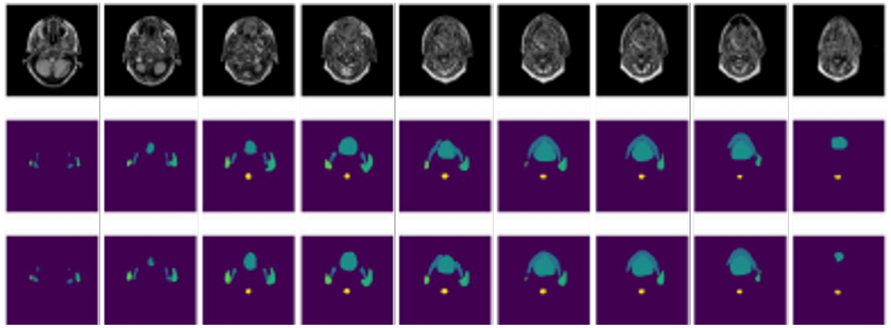

Figure 2. Visual results of multi-organ contours. The first row shows one patient's MRI HN image in axial view. The second row shows their corresponding manual contour of esophagus, larynx, mandible, oral cavity, left parotid, right parotid, pharynx and spinal cord. The row column shows the segmented contour of these organs.

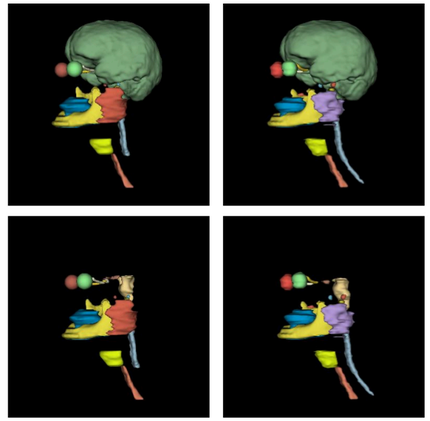

Figure 3. Visual results of 3D view. The first column shows the manual contour and the second column shows contours generated by the proposed method. The brain is removed in the lower two rows for better visualization of the brainstem contour.

CONCLUSIONS

- We have proposed and investigated a novel deep learning-based fully automatic HN multi-organ segmentation algorithm for MRI of HN cancer patients. The accurate HN OAR delineation enables further development of MRI-only based radiotherapy workflow for HN cancer
- The novelty of our approach lies in two aspects: 1) In order to force the backbone network focus on differentiate OAR tissues, a feature pyramid network (FPN) with deep attention strategy is used as backbone to get rid of noisy and uninformative features, and highlight the informative features that can well-represent the different OARs. 2) Instead of directly adopting conventional mask R-CNN architecture, the mask scoring strategy is used for supervising the prediction of the location and size of ROIs for each OARs. In original mask R-CNN algorithm, the ROI class score was used to rank the top ROIs for consolidation and aggregation.

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